

Society's 'Proceedings' for the same year (page 557). In that paper I described a new Frog, which I proposed to name *Pachybatrachus robustus*. I now find that, by a singular coincidence, the very same generic term was applied about the same time by Professor W. Keferstein, M.D., of Göttingen, to another new Batrachian. This appears in the third number of the 'Archiv für Naturgeschichte' for 1868, where, at page 273, Professor Keferstein has published a description of his *Pachybatrachus*. I therefore beg leave to withdraw the name which I before gave, and to substitute for it the more appropriate term *Clinotarsus*. I propose therefore that my new Frog should bear the name *CLINOTARSUS ROBUSTUS*.

2. Observations on *Lepus americanus*, especially with reference to the Modifications in the Fur consequent on the rotation of the Seasons, and the Change of Colour on the advent of Winter; based on Specimens obtained in the province of New Brunswick, North America. By FRANCIS H. WELCH, Assistant-Surgeon, 1st Battalion, 22nd Regiment\*.

This species is the sole representative of the *Leporidae* in the province of New Brunswick. In the List of Mammalia of the Portland Natural-History Society it is called the "White Hare," and in the 'New York Fauna,' by De Kay, the "Northern Hare." It is also termed the "American Varying Hare," and was for a long time confounded with the *L. variabilis* of Europe. Its geographical range appears as yet undetermined. According to Sir John Richardson it "is found as far north as 64° 30', Fort Enterprise, forming the staple food and clothing of the Hare Indians on the banks of the Mackenzie River." Its southerly limits are given by De Kay as "the northern parts of Pennsylvania and the mountain-tops of the northern part of Virginia." Of the many species of *Leporidae* inhabiting the North-American continent, it appears to be the only one that undergoes a complete change of colour during the winter†,—the Greenland Hare remaining white during the whole year, *L. nanus* becoming of a lighter hue, and occasionally iron grey, during the winter months, and *L. glacialis* assuming occasionally in the adult a greyish tint during the summer, limited to the points of the hair, the deeper parts remaining white permanently, the young, however, being horn grey, and changing to white on the advent of winter‡. Its weight varies—in its southernmost limits reaching 6½ lbs.; in New Brunswick averaging 3 lbs.; in Hudson's Bay Territory 4 lbs.

\* Communicated by Mr. G. Busk, F.R.S.

† *i. e.* provided the *L. campestris* be only a variety of *L. americanus*, as stated by Sir J. Richardson, but denied by Baird.

‡ Fauna Boreali-Americana.

This Rodent is described in the 'New York Fauna' by De Kay; but I believe, up to the present time, no detailed account of the fur-changes in sequence to the seasons has appeared. Its representative among the European species is *L. variabilis*, the process of change in which is summed up in the 'Naturalists' Library' (vol vii.) as follows:—"From the examination of individuals at different periods of the year, I have inferred that in this species the hair is almost always changing; that in April and May there is a general but gradual shedding, after which the summer colours are seen in perfection; that towards the middle of autumn many new white hairs have been substituted for coloured ones; and that by degrees all the hairs and under-fur are shed and renewed before the end of December, when the fur is in the perfection of its winter condition, being closer, fuller, and longer than in summer." In the 'Edinburgh Philosophical Journal' (vol. xi. p. 191) the conclusion arrived at is that "during the whole of this remarkable change in the fur no hair falls from the animal; hence it appears that the hair actually changes its colour, and that there is no renewal of it." Thus, in the former article the change is attributed to an autumnal shedding and new winter growth; in the latter to a change of colour only in the existent hair. I propose in the following remarks to enter fully into the details of the process, as illustrated by *Lepus americanus*.

In order to appreciate fully the cycle of changes in the coat of this Rodent in sequence to the rotation of the seasons, it seems best to take the summer dress as our starting-point, and inquire into the varieties of hair entering into the composition of the fur at this period, for the better elucidation of the part each individually plays in the subsequent phases; for in scientifically inquiring into the change of colour in the fur-bearing animals, it is essentially necessary to make a clear distinction between that resulting from alteration of colour in the already existent coat, and that consequent on a fresh undergrowth, which by gradual increase may eventually obscure the summer and autumnal hues. Each portion also of the skin must be separately examined, and individual peculiarities noted. The summer dress may be described as follows:—Back and sides of a glistening fawn-colour, interspersed with black, especially over the vertebral ridge; tail white; face and ears reddish brown, sparsely variegated by black hairs; edges of ears externally black or dark brown, increasing towards the tips; internally whitish, especially posteriorly; whiskers and eyebrows black; margin of lids dark brown or black, pupil the same, iris yellow; underparts white; anterior surface of feet light brown, the treading surface dirty white with hair very wiry. On examination, the components of this coat will be found to vary according to the portion of the animal examined; consequently it is necessary to enter somewhat into details.

In the fur are to be distinguished the external firm hairs constituting the pile and determining the colour, and the soft woolly undergrowth constituting the thickness of the coat and mainly instrumental in the retention of the animal heat. On the back the pile is made up of firm, straight, pointed hairs of diminished thickness

at their insertion into the skin, divisible into two varieties as to length and colour,—the one, in the minority, entirely black, average length  $1\frac{2}{10}$  inch; the other, black at extreme tip, succeeded downwards in the shaft by a well-defined tawny band again merging into black, which fades into light brown at the attached extremity, average length  $\frac{9}{10}$  inch. The delicate, wavy, flocculent undergrowth is of a slaty hue, passing into reddish brown at the free extremity, and of an average length of  $\frac{1}{2}$  inch; the commingling of the hairs *in situ* produces five zones of colour in the coat, viz. (proceeding from within outwards) slaty blue, reddish brown, brownish black, tawny, black. On the underparts the components of the fur are the same, of finer texture; the pile being entirely white lightens the hue of the undergrowth, which is slaty blue. No undergrowth is present on the ears, except at the base, and is very slight on the head and feet, especially on the treading-surface; here the hairs are of the same length, wavy in outline, and wiry in character. On the head, ears, and feet the pile is made up only of the shorter coloured hairs; at the nape of the neck only the undergrowth is present.

The autumnal coat is characterized by an increase in length of the outer hairs and undergrowth, generally over the whole body, and more appreciable as winter approaches.

About the commencement of October the first indications of the hybernal change are to be detected: the nose and lips assume an iron-grey hue, from the presence of white hairs; many of the whiskers are white at the tip or some portion of the shaft; a patch of white hairs, twenty to thirty in number, of the size of a split-pea, forms on the centre of the forehead\*; white hairs become apparent on the edges of the ears outside and at their junction with the neck, while on the inside a crop of downy white fluff springs up; a few of the longer hairs of the pile of the back, especially towards the tail, are observed to be blanched wholly, or only at the tips, while the greater part of the smaller kind are brown at the tip, with the tawny band of the shaft much lighter in colour or even white; the anterior surface of the feet, especially of the hind ones, is mottled with white.

Thus far the most careful examination fails to elicit any addition to the autumnal coat, the change being superficial and entirely dependent on an alteration of colour in existent hairs; the hind feet are the most advanced, then the ears and muzzle, lastly the back. During November this surface-change gradually deepens in intensity, especially around the tail, and on the feet, ears, and face (on the latter by a white streak extending from nose to eyes and upwards to the ears), and is accompanied by a deeper one of a much more potent character; for on separating the fur a thick crop of white stiff hairs (first apparent at the root of the tail) is to be detected springing up over the back and sides. These hairs, at first extremely minute and entirely of a new growth, rapidly increase in length, accompanied by an advance in the superficial changes above mentioned; soon they are

\* "Fancy Rabbits have often a white star on the forehead, and so has the young of *L. americanus*, like the English Hare" (Darwin, *Animals and Plants under Domestication*, vol. i. p. 140).

on an equality with the pile of the autumnal coat on the sides, forming a mottled whity-brown band from ears to tail, contrasting strongly with the centre of the back, at present comparatively unchanged; anon they outstrip this, reducing the mottling on the sides to a pure white, and, gradually implicating the centre of the back in the same process (through the varying hue-phases, according as the rapidly advancing white growth appears through and finally overwhelms the variegated changing autumnal coat), they clothe the animal in a thick white outer garment, generally assumed about the first week of December. As soon as the new growth renders itself superficially evident, the change of colour in the old hair, which on the back up to this time has been slow in progress, advances with great rapidity, so that in a few days only a few coloured hairs, generally remaining unchanged throughout the whole winter, are to be detected. The feet and ears, the first to show indications of change, are the last in completing the winter hue: generally the head and ears have no hybernal fresh growth; but occasionally it is to be met with. During this period, and especially when the new hybernal growth of white hair renders itself conspicuous on the surface of the autumnal coat, an extremely handsome fur is produced; every degree of variation may be met with, and each step of the process can be traced with accuracy and clearness. Modifications of the progressive changes enumerated above often occur in individuals, from an anticipation or retardation of change in one part relatively to the whole; these, however, are of a temporary nature—mere individual peculiarities, and finally merge into the all but universal midwinter clothing, which may be described as under. A white, with a leaden tinge, from a few long black hairs undergoing no change, pervades the entire skin, with the exception of the edges of the ears, eyelids, and legs; a narrow rim of black hair,  $\frac{1}{5}$  inch wide, is present at the tip of the ear externally and  $1\frac{1}{2}$  inch downwards on each side of the cartilage, which is thrown into strong relief by the thick white woolly coat now existent on the inside; a narrow rim, also black, on the free edge of the eyelids; the whiskers white entirely, or interspersed with some not changed, the shaft of hair white only at tip, or with alternating white and black bands; the anterior surface of the feet mottled reddish white,—the colour of the ears and eyelids being the resultant of no change in these situations, that of the feet and whiskers from a non-completion of the process. However, although this is the general rule, yet it is not difficult to find specimens where the length of the hybernal growth on the ears and around the eyes conceals the normal black, and the absolute completion of change elsewhere obliterates these peculiarities, leaving the animal snowy white, broken only by the glistening dark-brown pupil of the eye and yellowish iris.

Contrasting the winter with the summer and autumnal coat we find a colour-change with a great increase in the length and thickness of the fur; let us inquire minutely into the process and its local modifications. On the back is to be distinguished the pile and undergrowth. The former is made up of straight pointed hairs, slightly varying in length, the average  $1\frac{8}{10}$  inch, and white throughout the entire shaft, mingled with a few isolated black hairs and

reddish-brown ones with white tips: these latter are evidently unaltered or partially changed summer varieties; but the mass of the pile, treble increased in number and at least half an inch in length, is the produce of the hybernal growth superadded to the elongated and blanched autumnal coat. The under-fur has increased  $\frac{4}{10}$  inch in length, but is unaltered in thickness or colour. A crop of white hair has sprung up on the inside of the ear, on the outside and on the face the hairs have increased in length, and the shaft is partially or wholly whitened from the tip downwards. In most specimens no new hybernal growth is perceptible in these localities, in some there is a slight addition, in a very few it is as complete as on the back. However, where no increase in number ensues, compensation is effected by an extra augmented growth in the existent fur. On the legs the change is limited to a lengthening and bleaching of the outer hair; often this is limited to the tips of the shaft; and an occasional absence of change in spots leaves an irregular fawn-coloured mottling and streaking, especially on the front paws; the hair on the treading surface is lengthened and dirty white. On the underparts there is no addition beyond an increase of length of the fur; occasionally the whiskers and eyebrows remain black. Thus the winter hue would appear to be brought about by a change of colour in the pile of the autumnal coat combined with a new hybernal white crop, the latter undoubtedly playing no small part in the colouring process and in the thickening of the fur. There is no indication of shedding. An increase in length ensues over the whole body. On the underparts the change is limited to this, but elsewhere it is associated with a bleaching of the pile, generally commencing at the tip of the hair and involving part or the whole of the shaft. On the feet, and generally on the outside of the ears and face, no additional growth is perceptible; but on the inside of the ears, and over the whole back and sides, a thick crop of white hair springs up as the winter advances, and, blending with the changed surface, materially increases the thickness of the fur, protects the animal against the inclemency of winter, and assimilates it in colour to external nature. The process may be summed up as a combination of colour-change (except in the underparts) of the lengthened outer hairs of the autumnal coat, with an additional hybernal growth; the former universal over the body, the latter limited to certain portions.

The shaft of the hair of the new growth is invariably white, a circumstance which renders it easily distinguished from the autumnal hair in process of change. Careful examination of a great number of these latter hairs will render it evident that, although the bleaching process commences, perhaps, most frequently at the tip and proceeds downwards, involving the whole or a part only of the shaft, yet it is easy to obtain specimens (especially among the shorter variety of the pile) demonstrating its commencement at the centre, and occasionally at the attached extremity. The whiskers, which apparently do not lengthen but merely alter in colour, will demonstrate each variety.

Microscopically examined, the hair of this Rodent, circular in outline, is composed of oval or irregular shaped cells placed end to

end and arranged in linear series in the long axis of the shaft, covered externally by a delicate tissue of elongated flattened epithelium (fig. 2). The shaft of the under-fur (fig. 1) averages  $\frac{1}{2000}$  inch in thickness, has one series of cells in its structure; the pile,  $\frac{1}{600}$  inch in diameter (fig. 3), four or more, according to the varying thickness of the shaft,

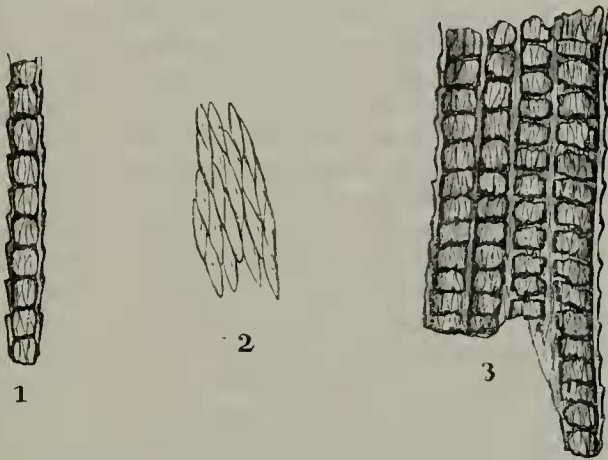


Fig. 1. Microscopic aspect of shaft of under-fur.  
2. Epithelial covering of shaft.  
3. Shaft of pile.

one series only at the tip, and the number gradually augmenting to the greatest circumference—the cells varying in colour according to the portion examined, but when white to the naked eye then colourless microscopically. The increase in the length of the autumnal hairs has been already noted; to this must be added that the blanching shaft, in the majority of cases, has also augmented in thickness, the average  $\frac{1}{330}$  inch in diameter (corresponding to the new growth), the increase being consequent upon a more than usual number of series of cells entering into its composition. In some hairs where the centre of the shaft has changed, bounded on each side by an unchanged portion, it will be noted that at the altered segment the shaft bulges out, increasing in diameter from  $\frac{1}{600}$  to  $\frac{1}{400}$  of an inch by the addition of one or more series of colourless cells, and that at the unaltered portion, both above and below, it is contracted to the former size, contrasting strongly both in the number of series of cells and in the absence of colour in the changed parts. If also we examine one of the long black hairs bleaching at the tip, the addition of the colourless cells, as contrasted with the same portion of an unchanged hair, is very marked. Again, a comparison of changed hairs with unchanged ones of almost equivalent length, from the same vicinity, gives frequently a double thickness to the former over the latter. The increase of series to the shaft of the hair in process of change seems the rule, the absence of colour invariable; but in the whiskers, which in their structure approach rather the human hair with its fibrous cylinder and cellular centre, the former is not so apparent.

What is the *rationale* of the process in virtue of which to the naked eye the colour of the hair is changed from black or tawny to white? Is it dependent on an abstraction of pigment, an alteration, or new deposition? and must we regard it in the light of some general condition of the animal frame modifying the whole capillary pigmentary secretion, or, on the other hand, interrogate the hair itself for the solution of the problem? The gradual character of the process, the immunity of some hairs from all change whatever, the irregularity of its course in involving different hairs in the same portion of the body, the all but invariable commencement of change in any other part of the shaft than that first to be influenced by altered secretions, the temporary localization of the process to some one part of the shaft, entirely limited to this or gradually implicating the rest, and the freedom from all change in colour in the under-fur, incline the balance of evidence to the latter opinion, and, moreover, indicate a capability of action of one portion of the shaft of the hair independently of any general change affecting the whole, and derived from the organism within. It would seem that the rapid development of new hairs, varying in no appreciable respect except colour from the pile, called forth by the increasing rigours of climate for the protection of the animal frame, involves the autumnal outer fur in the same process, leading to an increased length and thickness in the shaft of the hair by the superposition of layers of the same colourless cells entering into the structure of the new growth—perhaps combined also with an arrested production of pigmentary matter.

Although, as a general rule, it may be stated that the hybernal change commences about the first week in October, and is finished the first week in December, thus occupying two months, yet departures from it are not at all uncommon, both as regards the comparison of one individual with another at the same period of time, and as regards the modifications consequent on yearly climatic variations. For example, a specimen shot in December 1866 was only beginning to turn white. On November 6th, 1867, a skin (before the first fall of snow) had a head piebald, feet white, back with a scattered white hair, no undergrowth. On November 18th (after the first fall), two Hares were shot in the same vicinity, one changing, the other not. On the 22nd, from a high ground, one was perfectly white on head and feet, and on each side and around the tail deeply patched of the same colour; the other showed only slight superficial changes, but on separating the fur the new growth was easily detected,  $\frac{1}{5}$  inch in length, hidden under the autumnal coat. Again, on the 21st one was in the same state as the preceding, while another from the same vicinity presented a dark streak along the centre of the back gradually fading into the white sides; change elsewhere accomplished except on centre of forehead. On the 28th one was pure white. In the first week in December 1868 one was complete in the change; another was still very brown along the spine. On the 11th December 1868 three were examined,—one, ears not whitened at all in front, feet very reddish, body changed; another, feet changed, side of face mottled, centre of back not yet implicated; the third, complete except a patch on each side

of the face. Although the examples quoted demonstrate how individual peculiarities, apart from age, sex, or habitation, may modify a general law, there can be no doubt that the change is essentially dependent on the season, and is hastened or retarded by its severity or otherwise. On the seaboard it is postponed in comparison with inland districts in the same latitudes. Sir J. Richardson remarked the early change of *L. americanus* in the Hudson's Bay Territory, as well as the carrying of its winter coat until June. He also especially mentions "the absence of change of dress in the winter time in the southern parts of the United States"\*. I am informed that one kept in confinement at St. John's, N. B., in a warm barn, retained the summer colours. Respecting the popular idea of the white-fur coinciding with the first fall of snow, careful observation does not corroborate it. The change is essentially gradual, and spread over some seven weeks; but the rapidity with which the new white growth, when it first renders itself apparent externally, involves the entire surface of the back may somewhat explain the popular belief on the subject, although at least seven days must be taken up in this part of the process.

The winter's coat is generally carried in New Brunswick until the middle of May, when it is gradually shed, so that in June the animal may be said to have assumed its summer fur. Thus five months may be regarded as the period during which in this province *L. americanus* is clothed in white—from December to April; two months are occupied by the autumnal change, and one by the vernal. We have seen how in the Arctic regions the duration of the winter coat is extended, and its absence in southern latitudes. Considering the increased duration of the winter coat over the summer one in proportion to the seasons, as well as its importance to the animal in assimilating it to the natural features of the country for the greater part of the year, and as a protection against cold and its numerous enemies, it would be rational to regard the winter fur as the ordinary coat of this Hare in New Brunswick and northern climes, and the summer change its modification; the opposite would hold good in more southern latitudes, in sequence to the relative length of the seasons.

The dimensions of this Rodent, as met with in New Brunswick, are as follows:—

	ft.	in.
Length from nose to end of tail . . . . .	1	6
— from ear to end of hind leg stretched . . . .	2	5
— of ears . . . . .	0	3
— of head . . . . .	0	3.75
Fore leg, from middle toe to ulna extremity . . . .	0	6
— —, from wrist-joint to middle claw . . . . .	0	2.9
Hind leg, from middle claw to hip-articulation . .	0	12
— foot, from middle toe to calcis . . . . .	0	6
— —, breadth posteriorly . . . . .	0	0 $\frac{3}{4}$
— —, breadth anteriorly . . . . .	0	1 $\frac{3}{4}$
— —, " " when expanded . . . . .	0	4
Average weight, 3 lb.		

\* Appendix to Parry's Arctic Expedition. *L. americanus*.

Thus the peculiarity of *L. americanus* consists in the development of the feet relatively to the body generally, as contrasted with other species. Although only weighing 3 lb. in New Brunswick, against  $6\frac{1}{2}$  lb. in southern districts, with a corresponding diminution in the dimensions of the body, the feet yet retain fully as great development in one as the other. *L. timidus*, with an average weight of 8 lb., and length 26 inches, has a hind foot only  $5\frac{1}{2}$  inches long; whilst *L. variabilis*, with an average length of body of 23 inches, has also  $5\frac{1}{2}$  inches. *L. glacialis*, found in common with the American, 7 lb. weight, and 22·6 inches long, has dimensions as follows:—from wrist-joint to end of claw 2 inches 9 lines, heel to point of middle claw 5 inches 9 lines. Not only is the foot of *L. americanus* proportionately lengthened, but a remarkable degree of lateral extension is allowed between the metacarpal and metatarsal bones, with great laxity of the web membrane. Inhabiting the woody districts, where the snow remains deep and soft during the greater part of the winter, the advantage of such a modification in the feet, especially when combined with the lengthened stiff winter hair on the treading-surface, is apparent, allowing it to pass over the softest snow with the slightest impress, and thus giving it the power of eluding by swiftness its numerous enemies. A recent impress of these natural snow-shoes gave the following shape and dimensions:—Fore feet oval, each  $3\frac{1}{2}$  inches long by 2 inches broad. Hind feet egg-shaped (large end anteriorly), each 6 inches long by 3 inches in front and  $1\frac{1}{2}$  inch behind.

The average snow-shoes adapted to an ordinary-sized man have a superficial area  $5\frac{1}{2}$  inches for each pound in weight, which is extended in this Rodent to 11·4 inches. In the Hudson's Bay Territory *L. glacialis* and *L. americanus* exist in the same district, the one inhabiting the open barrens, the other the soft snowy woodlands.

It appears much to be desired that the modifications in the feet and winter coat of this Rodent, under different latitudes and variations of natural conditions, should be accurately traced out, inasmuch as the indications are that, both in the one and the other, they fully illustrate the capability of external circumstances to call forth structural changes, placing the animal frame in harmony with the surrounding natural features, and allowing it to compete advantageously with its numerous and powerful enemies in the great struggle for existence.

### 3. Notes on the Habits of the Collared Plain Wanderer (*Pedionomus torquatus*, Gould). By W. VINCENT LEGGE, F.Z.S.

Mr. Gould says this bird is not uncommon in South Australia, where it inhabits the plains of the interior; but I think he does not record its presence in Victoria. It makes its appearance in